WASTE COAL RECLAMATION

by

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One of the major problems facing the electric power generating industry is the ever increasing demand for energy coupled with a real and vociferous public demand for reduced pollution levels. A partial solution to this dilemma could lie in the redemption of waste coal piles (gob or culm banks) which would result in the production of needed energy while reducing the ecologic and aesthetic problem these banks currently represent. Although this study was based upon banks present in the Monongahela River Drainage Basin in Southwestern Pennsylvania, Northern West Virginia and parts of Maryland, the conclusions to be drawn will be applicable with minor modifications to other coal mining areas of the U. S.

A waste coal pile or culm bank is heterogeneous rather than homogeneous in composition and variation will occur, both horizontally and vertically. Culm bank materials in the Monongahela Basin will generally consist of coal, shale, bone coal, sulfates, carbonates and pyrite (FeS_2) or marcasite (FeS_x). In addition, slag materials may be present if combustion of portions of the bank has occured. The relative amounts of each constituent will be dependent upon such factors as the market for which the coal was cleaned and the methods of cleaning, the efficiency of the cleaning process, the mining methods and systems employed and such natural factors as the quality of the coal seam. In order to illustrate the effects of the many variables upon the composition of the materials being placed on a culm bank, a hypothetical history of an imaginary culm bank is included. While no such bank may actually have been formed, many of its features can be seen in existing banks. Figure 1 has been prepared to show the major markets for bituminous coal from 1917 to 1956. The history of a mine in its cleaning facility and its resultant culm bank could therefore be as follows:

1917--A coal mine is opened and a picking and screening facility is constructed to help supply an existing market for metallurgical and railroad locomotive fuel and for fuel for industrial and commercial heating plants as well as for household furnaces. Mining is not yet mechanized to any extent, and waste material from the picking and screening facility contains mainly hand picked pieces of rock and coaly material along with the undersize material for which no steady market exists. This fine material is predominately coal and is mixed with the waste rejects and discarded. Due to the method of dumping, the softer, more friable materials tend to be concentrated in the interior of the pile while the harder,higher ash, hand sorted materials accumulate along the edges.

1920--Coal production and coal sales are dropping. In order to retain markets, greater selectivity in mining is employed and the preparation facility is enlarged and improved to produce a higher quality coal. Additional pickers are hired and more rigorous sorting and sizing are initiated. The ash and the sulfur content of the coal being marketed are sucessfully reduced, and more fine coal is being deposited on the pile.

1923--A new market for intermediate quality coal develops with the construction of an electric power generating station nearby. In addition, gas and oil are beginning to replace lump coal as the common fuel for commercial boilers and household furnaces. A buyers market still exists and the waste material being placed on the pile continues to be high in fine coal content. Due to the need to remain competitive, some machinery is introduced into the mine with the result that less preliminary cleaning and selection occurs during mining. Consequently, more rock, fines, and other dilutant materials are handled at the preparation facility and more material having high ash and sulfur content is discarded to the pile.

1925--The demand for high quality metallurgical and intermediate quality power plant fuel continues to increase. Concentrating units are added to the screening and picking facility. The waste materials reaching the bank now contain less fuel values and are relatively higher in rock and ash constituents than during any previous period.

1929--A major decline in the national economy begins and will continue for several years. In order to sell coal in a declining market, rigorous preparation is practiced, thereby maintaining competitiveness in a seriously oversupplied market. Although growth of the culm bank is limited, a relatively large amount of coal fines improve the fuel value.

1933--The marketing situation for coal is unstable, but the trend appears to be upwards. Additional mechanization takes place in the mine with the result that fluctuating tonnages of high ash and high fuel value material are intermittantly being placed on the culm bank.

1940--World War II is approaching, and increasing industrilization is creating a demand for all forms of energy. A seller's market exists and before it peaks in 1943, many existing culm banks will be spot loaded to recover pockets containing high fuel value materials. Material entering the culm bank is high in ash and moderate in sulfur and because of spontaneous combustion and the mining of the richer pockets the bank is becoming increasingly deficient in fuel value.

1945--The advent of the diesel engine signals the beginning of the end of the railroad locomotive market. Also, other domestic markets are declining. Power stations and metallurgical coking ovens are the only growth markets for coal. More advanced cleaning and mining methods continue to be installed at the facility and a high ash, high sulfur and moderate fuel value material is placed on the culm bank.

1950--The power station is modernized and pulverized fuel boilers are installed; moreover, increasing tonnages of clean, high quality metallurgical coal are produced and marketed. More mechanical equipment is introduced into the mine. At the plant, crushers are installed and the cleaning process is made more efficient. As a result of the demands for a high quality metallurgical product and the willingness of the power station to accept a lower cost middling quality fuel, the waste material being place on the bank is very lean in fuel values and has a high ash and sulfur content.

1969--Increasing safety legislation causes more water to be used in the mine and more diluent material to be removed. The ash or mineral content of the coal entering the cleaning plant continues to increase. Much more material enters the culm bank of high ash content and low to to moderate fuel value. Older sections of the bank are being mined to recover previously discarded fuel values as a result of a seller's market.

1972--A major change occurs as a result of air pollution control legislation. Coal is now being sold to utilities on the basis of sulfur content rather than on the traditional BTU value. In order to meet the new requirements, new and more costly methods of concentration are employed and large tonnages of medium ash, high sulfur and high fuel value material are being placed on the bank. In addition, more of the older portions of the pile are being mined for the moderate ash, moderate sulfur fuel values placed there previously.

While this history is of necessity brief and overly simplified and such a culm bank is purely hypothetical, it can serve to illustrate some of the complex inter-acting factors which determine the composition of the material present at any specific location within the pile. It can also serve to illustrate the extreme care which must be taken to obtain representative samples for the pile. The decision to reclaim fuel values from a particular bank should be based on a combination of sample data and a knowledge of the bank's history.

Older piles, formed using simple dumping methods, will often have a profile similar to that shown in figure 2. Such a pile will have general distributional zones which will reflect the different coal associated strata which were being mined. Assuming that the coal materials are relatively softer than the associated rock material, the coal would degrade more rapidly and the resulting finer particles would tend to migrate towards the center of the pile (zone A). This coal material will generally be relatively low in moisture and ash and high in Btu value. The material at the outer edge of the pile will generally be larger in size and will be more prone to combustion resulting in burnt out pockets of slag material.

More recent piles, in which the waste was laid down in layers and then compacted will tend to have horizontal pockets of relatively rich coal material alternating with layers of high ash, high rock content.

Affects Upon Power Plant Operations

It has long been known that materials with very low heating values can be burned. Coal refuse crushed to one-quarter inch size and with as little as 3,000 to 3,500 Btu heating value has been burned in the Office of Coal Research pilot scale fluid-bed column designed and operated by Pope, Evans and Robbins.[1] Coal waste with as little as 5,000 Btu heating value can be burned in specially designed, conventional boilers provided that the wastes are friable enough to permit economical grinding to a fine size.[2] Boilers designed to burn coal waste must be equipped with oversize ash handing capability since approximately one-half or more of the coal wastes fed to the boiler would remain as ash and would therefore have to be continuously removed.

The direct burning of lean gob piles to produce power is well established from experience in France where anthracite waste banks have been used up as a source of fuel during the past twenty-five years.[3] Combustion was achieved using the Ignafluid boiler which burns coal refuse crushed to approximately 1/4 inch. Refuse with a dry ash content as high as 40 percent and heat content as low as 7,500 Btu's was found to provide a satisfactory fuel. Moreover, it is preferable that refuse fed to an Ignafluid installation should contain between 15 to 20 percent volatile matter, less than 5 percent sulfur and have ash with a fusion temperature ranging from 2,000 to 2,6000°F.

[1]Private communication with John Bishop, Pope, Evans and Robbins, Alexandria, Virginia.
[2]Private communication with Combustion Engineering Company, Windsor, Connecticut.
[3]Private communication with Paul A. Mulcey, Consulting Engineer, Dallas, Pa.

Most present coal burning power plants operate with coal having fuel values ranging between 10,000 and 12,000 Btu per pound and with ash contents ranging up to approximately 30 percent. The refuse from most banks can be mixed directly with coal provided that the heating value and ash content of the mixed product meets the Btu design level of the boiler for which the fuel is intended.

Economic Utilization Potential

The attached table is included to provide preliminary information about the size and composition of some randomly selected refuse banks in the Monongahela River Drainage Basin.

Test increments for banks of various sizes are reported in the table under composition on an as received basis. Composition includes volatile matter, fixed carbon, ash, sulfur and Btu values. Because an extensive and long term sampling program would be required to establish the composition of all banks in the area, no conclusions are offered concerning the quality of the total deposit. Nevertheless, it is interesting to note that 8 of the 20 increments contain a volatile matter content of greater than 19 percent while 14 of the 20 increments contain heating values greater than 3,500 Btu with the result that nearly 75 percent of the bank increments meet at least one of these generally favorable characteristics. Had these increments been beneficated, there is little doubt that considerably more than 75 percent would yield a product with 3,500 Btu and/or 19 percent volatile matter on an as received basis.

While the preceding estimates provide a measure of the relative number of bank increments that might be utilized in new or specially desingned boilers, it is equally important to note the relative number of bank increments that might qualify for utilization as a fuel for the already commercially available Ignafluid process. Hence, 3 out of 20 bank increments would appear to readily qualify as an Ignafluid fuel and, with some benefication, as many as 14 out of 20 bank increments might be beneficated to meet specifications.

Finally, it would appear that the same raw and/or beneficated 14 out of 20 bank increments could be used in blends with higher grade coal for utilization in existing power stations.

The preceding information strongly infers that a high percentage of coal refuse banks in the Monongahela drainage basin could be burned in new, modified or existing combustion processes to produce useful power with the simultaneous benefit of converting unsightly piles of refuse to greatly reduced quantities of more readily utilized ash.

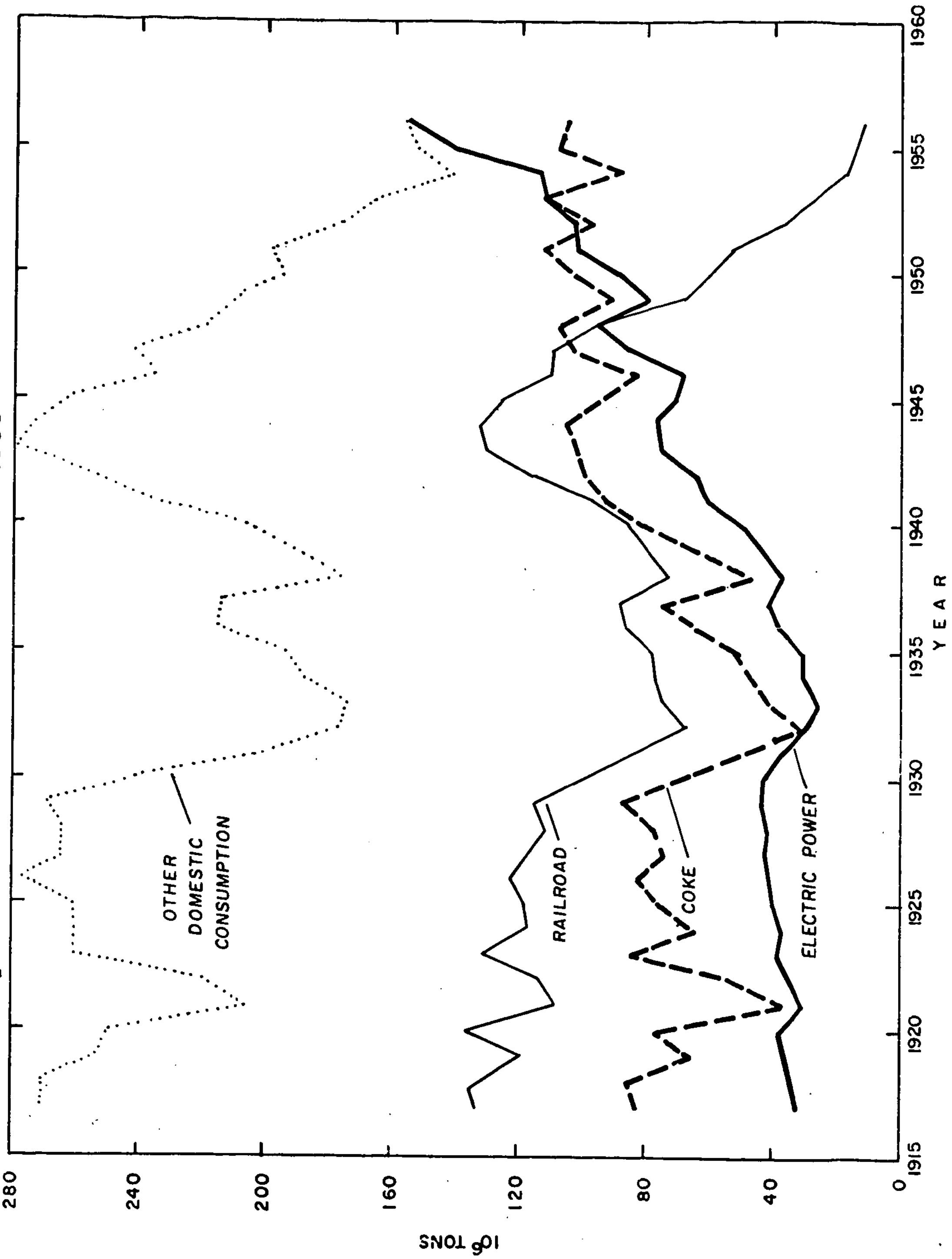
TABLE I

ESTIMATED SIZE AND COMPOSITION OF SOME RANDOMLY SELECTED COAL WASTE BANKS LOCATED IN THE MONONGAHELA RIVER DRAINAGE BASIN

Size		Composition* As Received Basis					
Cubic Yards	Acres	Moisture	Volatile Matter%	Fixed Carbon %	Ash %	Sulfur %	Btu
45,733,000	315	9.19	10.17	7.10	73.54	.31	1,589
8,219,000	102	16.29	16.20	19.21	48.30	2.02	3,943
7,644,000	39	7.61	12.80	9.50	70.09	.74	2,502
6,000,000	101	16.14	22.01	33.22	28.63	2.24	7,933
4,000,000	115	14.38	17.14	16.94	51.54	0.93	4,202
3,554,000	44	2.41	13.24	8.01	76.34	.69	2,225
3,000,000	32	19,50	16.16	7.18	57.16	2.23	2,315
2,800,000	44	8.28	15.97	21.15	54.60	.56	4,321
2,749,000	42	10.35	14.23	25.46	49.96	.81	4,802
2,000,000	29	9.08	26.38	41.08	23.46	1.14	9,611
1,400,000	23	9.60	25.34	23.51	41.55	7.17	6,475
1,299,000	27	23.62	16.38	9.50	50.50	2.59	2,467
871,000	6	11.29	14.89	21.18	52.64	0.83	4,547
700,000	5	9.30	19.41	23.64	47.65	0.78	5,828
600,000	21	13.80	19.30	24.31	42.59	1.34	5,756
200,000	5	9.18	15.98	30.21	44.63	.61	6,294
200,000	4	25.24	19.9	10.33	44.45	2.59	2,689
176,000	11	12.58	24.66	38.18	24.58	1.09	8,796
80,000	6	14.98	20.96	26.52	37.54	0.88	6,364
-	-	12.79	17.80	20.85	48.56	1.51	4,756

*Composition is based on analyses of some randomly selected increments of weight of refuse obtained from each bank, and should not necessarily be construed to be representative of the entire bank.

Figure I – COAL MARKETS 1917 — 1956



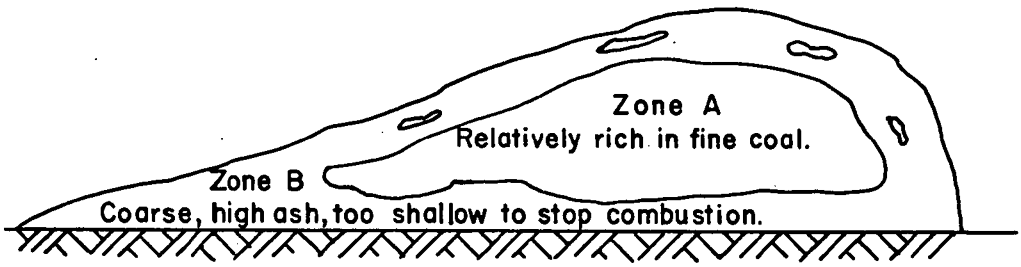


Figure 2 - PROFILE OF TYPICAL APPALACHIAN GOB PILE FORMED BY DUMPING RATHER THAN SPREADING AND COMPACTION.